

THIN FILM ELECTRODES WITH AN INTEGRAL CURRENT COLLECTION GRID FOR USE WITH SOLID ELECTROLYTES

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Thin film electrodes are used in solid state electrochemical devices such as the alkali metal thermal to electric converter (AMTEC), electrochemical pumps, and fuel cells. A requirement of such electrodes is that they (1) be porous enough to allow passage of fuel or working fluid as vapor (2) be electrically conducting, and (3) be refractory enough for operation at high temperature in possibly corrosive environments. Previous work from this laboratory has demonstrated the feasibility of including thick film grids in the electrode to increase electronic conduction while maintaining the capability of gas transport in the thin film areas [1]. These grids have been deposited on solid electrolyte using photolytic chemical vapor deposition (PCVD) of metals from organometallic compounds such as metal carbonyls. When tested an electrode with current collection grids, overall performance of an AMTEC increased 25-50% (measured power production) because of the decreased resistance in the electrode, in spite of 10-15% of the surface area of the electrode being occluded to vapor flow.

In previous work we have deposited grid lines using PCVD of a refractory metal such as molybdenum, followed by sputter deposition of a metal alloy electrode such as platinum-tungsten or rhodium-tungsten. While device performance was significantly improved, there are drawbacks to this approach. A very thin oxide layer may form on the surface of the grid before the electrode is sputter deposited over it, resulting in a contact resistance between the grid and the electrode. In addition, the differences in the coefficients of thermal expansion between the grid material and the electrode material may result in buckling or peeling of the electrode at the grid lines during operation at high temperature. Finally, the rate of grain growth of Mo metal is relatively rapid at temperatures above 1100 K and the operating lifetime of a device may be significantly shortened if Mo grids are used [2].

An approach to solving these problems is the use of integral grids and electrodes, where the grid and electrode have the same composition and are deposited simultaneously. In this way, there are no contact resistances between the grid and the electrode, and there is no difference in thermal expansion between the

electrode and the grid. It has been necessary to develop techniques for PCVD of metal alloys and to investigate the mechanism of deposition of two metals in the presence of each other [3]. We have made alloys of rhodium-tungsten in compositions varying from Rh₃W to Rh₈W₂ using [Rh(CO)₂Cl]₂ and W(CO)₆; different compositions were attained by varying the partial pressures of the rhodium and tungsten carbonyls in the deposition chamber during illumination. The electrical properties of these photodeposited films are similar to those of sputter deposited films. The mode of attachment to the ceramic electrolyte appears to be different for photodeposited and sputter deposited films, as the photodeposited films are significantly more adherent.

In addition to developing a technique for photodeposition of alloys, we have developed an approach to PCVD of integral grids + electrodes which takes advantage of the characteristics of photolytic chemical vapor deposition. It has been shown that metals will deposit preferentially at "pre-nucleation" sites, or sites where a metal deposit < 100 Å thick has been previously formed, under illumination which is not directed only at those sites [4]. New nucleation sites may be formed by increasing the illumination intensity, thus depositing metal in the entire illuminated area. Integral grids + electrodes may be made by taking advantage of this characteristic of PCVD.

Using PCVD, we have been able to make integral electrodes + current collecting grids of rhodium-tungsten alloys on β"-alumina solid electrolyte. These electrodes will be tested at high temperature in sodium atmosphere and compared to sputter deposited RhW electrodes of similar composition.

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2. M.A. Ryan, B. Jeffries-Nakamura, R.M. Williams, M.L. Underwood, D. O'Connor and S. Kikkert, *Proc. 27th Intersociety Energy Conversion Engineering Conference*, SAE, 3, 7 (1992).

3. M.A. Ryan, A. Kisor, R.M. Williams, B. Jeffries-Nakamura, D. O'Connor, *Extended Abstracts of the Electrochemical Society*, 93-2, #382.

4. D.J. Ehrlich, R.M. Osgood, Jr., and T.F. Deutsch, *J. Vat. Sci. Technol.*, 21, 23 (1982).